Performance and Emission Evaluation of DI Diesel Engine Using Cotton Seed Oil As Alternative Fuel

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ABSTRACT:- **Increase in energy demand, stringent emission norms and depletion of oil resources led to find alternative fuels for internal combustion engines. Many alternative fuels like alcohols, bio-diesel, liquid petroleum gas (LPG), compressed natural gas (CNG), etc have been already commercialized in the transport sector. In this context cotton seed oil renewed interest. The cotton seed oil can be converted in bio diesel using a process called as trans-esterification. The cotton seed oil is blended with diesel and used as an alternate fuel for CI engines. In the present work performance characteristics and emissions are evaluated on single cylinder four stroke diesel engine fuelling with 10%, 20%, 30%, 40%, 50%, 60%, for cotton seed oil by volume. Due to high viscosity and soot formation, above 60% was not taken in cotton seed oil- diesel blend. Experiments are carried out on a diesel engine, which is single cylinder four stroke engine capable of developing a power output of 7.5KW at 1500 rpm. Performance parameters such as Brake Power, Specific Fuel Consumption, Indicated Thermal Efficiency, Brake Thermal Efficiency, Volumetric Efficiency, Mechanical Efficiency, Brake Mean Effective Pressure and Indicated Mean Effective Pressure are calculated based on the experimental analysis of the engine. Emissions such as Carbon Monoxide, Hydro Carbons are measured.**

KEYWORDS: ***Emissions, trans-esterification, Internal combustion engine, Cotton Seed Oil and Efficiency.***

1. INTRODUCTION

Compression ignition engines are employed particularly in the field of heavy transportation and agriculture on account of their higher thermal efficiency and durability. However, diesel engines are the major contributors of oxides of nitrogen and particulate emissions. Hence more stringent norms are imposed on exhaust emissions. Following the global energy crisis in the 1970s and the increasingly stringent emission norms, the search for alternative renewable fuels has intensified.

Probably in this century, it is believed that crude oil and petroleum products will become very scarce and costly to find and produce. Although fuel economy of engines is greatly improved from the past and will probably continue to be improved, increases in number of automobiles alone dictate that there will be a great demand for fuel in the near future.

2. LITERATURE SURVEY

The gradual depletion of world petroleum reserves, increases in prices of petroleum based fuels and environmental pollution due to exhaust emissions have encouraged studies to search for alternative fuels. In view of these, vegetable oil has been considered as alternative fuels for compression ignition engines. Vegetable oils are renewable, nontoxic, biodegradable, and have low emission profiles [1–5]. However, there are some drawbacks related to the use of straight vegetable oils in diesel engines primarily due to their high viscosity, lower volatility and lower heat content [6–8]. The high viscosity causes some problems in atomization of injector systems and combustion in cylinders of diesel engines. Also, in long term operations, high viscosity of vegetable oils may lead to ring sticking, formation of injector deposits, development of gumming, as well as incompatibility with lubricating oils [1, 9].

Different techniques have been developed to solve their high viscosity and low volatility problems of vegetable oils, such as preheating oils, blending or dilution with other fuels, Trans-Esterification and thermal cracking/pyrolysis [1, 2, 10–12]. Trans-Esterification appears to be the most promising technique which is a chemical process of converting vegetable oil into biodiesel fuel [5, 11, 13 and 14]. Biodiesel can be used as a blend in diesel engines without modification. Detailed reviews about trans-Esterification process are available in the literature [2, 12]. The price of edible vegetable oils is higher than that of the diesel fuel. Therefore, instead of using such oils, the use of waste vegetable oils [18] and non-edible crude vegetable oils [11] has been considered as potential alternative fuels.

A single cylinder compression ignition engine is used to compare the Performance and Emission and Combustion characteristics between pure diesel and Cotton seed blends [24 and 25]. The Cotton seed oil blends are in percentage of 0%, 10%, 20%, 30%, 40%, 50%and60% of Cotton seed oil to 100%, 90%, 80%, 70%, 60%, 50% and 40% of diesel. Results show that methyl esters of Cotton seed oil (CSOE) Exhaust emissions and Combustion characteristics of methyl esters of Cotton seed oil (MEON) were within limits. Hence methyl of Cotton seed blend can be used in existing diesel engines without compromising the engine performance.

In the present investigation, Cotton seed oil was considered as a potential alternative fuel for compression ignition engines. Specifications of the Cotton seed oil investigated and compared with other vegetable oils and this was the basic motivation behind the research in this project. The engine tests were carried out on a direct injection diesel engine fuelled with diesel fuel and10%, 20%, 30%, 40%, 50% and 60% Cotton seed oil-diesel blends by volume. The results were summarized.

3. MATERIALS AND METHODS

Rapid depletion of conventional energy sources, along with increasing demand for energy is a matter of serious concern. To solve both the energy concern and environmental concern, the renewable energies with lower environmental pollution impact should be necessary. Biodiesel is renewable and environmental friendly alternative diesel fuel for diesel engine. It can be produced by trans-esterification process. Trans-esterification is a chemical reaction in which vegetable oils and animal fats are reacted with alcohol in the presence of a catalyst. The products of reaction are fatty acid alkyl ester and glycerin, and were the fatty acid alkyl esters known as biodiesel.

a. TRANSESTERIFICATION OF COTTON SEED OIL

To reduce the viscosity of the COTTON SEED OIL, trans-esterification method is adopted for the preparation of biodiesel.

b. ESTER OF COTTON SEED OIL

The procedure involved in this method is as follows: 1000 ml of COTTON SEED OIL is taken in a three way flask. 12 grams of sodium hydroxide (NaOH) and 200 ml of methanol (CH3OH) are taken in a beaker. The sodium hydroxide (NaOH) and the alcohol are thoroughly mixed until it is properly dissolved. The solution obtained is mixed with COTTON SEED OIL in three way flask and it is stirred properly. The methoxide solution with COTTON SEED OIL is heated to 60 ^{0}C and it is continuously stirred at constant rate for 1 hour by stirrer. The solution is poured down to the separating beaker and is allowed to settle for 4 hours. The glycerin settles at the bottom and the methyl ester floats at the top (coarse biodiesel). Methyl ester is separated from the glycerin. This coarse biodiesel is heated above 100°C and maintained for 10-15 minutes to remove the untreated methanol. Certain impurities like sodium hydroxide (NaOH) etc are still dissolved in the obtained coarse biodiesel. These impurities are cleaned up by washing with 350 ml of water for 1000 ml of coarse biodiesel. This cleaned biodiesel is the methyl ester of COTTON SEED OIL.

TABLE NO 1.1 Properties of COTTON SEED OIL

PROPERTIES	DIESEL	COTTON SEED OIL
Kinematic viscosity at 40 ^{0}C (cSt)	2.68	55.61
Density at 15 ^{0}C (kg/m^{3})	828	912
Flash point (^{0}C)	56	207
Calorific value (kJ/kg)	43000	40,000
Sp.gravity	0.835	0.850

4. SPECIFICATION OF THE PROBLEM

In the present work the performance characteristics and emissions are evaluated on single cylinder four stroke diesel engine air cooled, which is capable of developing a power output of 7.5kW at 1500rpm, fuelling with 10%, 20%, 30%, 40%, 50%, 60%, for cotton seed oil by volume. Due to high viscosity and soot formation, above 60% was not taken in cotton seed oil- diesel blend. The Performance parameters such as Brake Power, Specific Fuel Consumption, Indicated Thermal Efficiency, Brake Thermal Efficiency, Volumetric Efficiency, Mechanical Efficiency, Brake Mean Effective Pressure, Indicated Mean Effective Pressure are calculated based on the experimental analysis of the engine. Emissions such as Carbon Monoxide, Hydro Carbons are measured.

5. EXPERIMENTAL SETUP

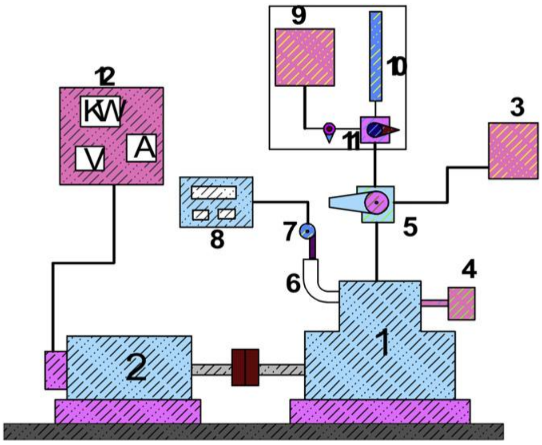

FIG NO.1. Experimental Setup

The experimental setup is fabricated to fulfill the objective of the present work. The various components of the experimental set up including modification are shown in fig no.1.

Various Parts of Experimental Setup

1. Alamgair Engine
2 Alternator
3. Diesel Tank
4. Air Filter
5. Three Way Valve
6. Exhaust Pipe
7. Probe
8. Exhaust Gas Analyser
9. Alternative Fuel Tank
10. Burette
11. Three Way Valve
12. Control Panel

a. EXPERIMENTAL PROCEDURE

Before starting the engine, the lubricating oil level in the engine is checked and it is also ensured that all moving and rotating parts are lubricated.

The various steps involved in the setting of the experiments are

1. The Experiments were carried out after installation of the engine
2. The injection pressure is set at 200 bar for the entire test.
3. Precautions were taken, before starting the experiment.
4. Always the engine was started with no load condition
5. The engine was started at no load condition and allowed to work for at least 10 minutes to stabilize.
6. The readings such as fuel consumption, spring balance reading, cooling water flow rate, manometer reading etc., were taken as per the observation table.
7. The load on the engine was increased by 20% of FULL Load using the engine controls and the readings were taken as shown in the tables.
8. Step 3 was repeated for different loads from no load to full load.
9. After completion of test, the load on the engine was completely relieved and then the engine was stopped.
10. The results were calculated theoretically and tabulated.

The above experiment is repeated for various loads on the engine. The experimental procedure is similar as foresaid. While starting the engine, the fuel tank is filled in required fuel proportions up to its capacity. The engine is allowed to run for 20 min, for steady state conditions, before load is performed.

There was no separation of diesel and cotton seed oil blends even at B50 and B60. f diesel.

Finally, the engine is run by blend (200 atm) at various loads and the corresponding observations are noted.

The test is carried on the single cylinder CI Engine for the following fuel blends:

1. 100% Diesel
2. 10% Cotton Seed Oil + 90% Diesel
3. 20% Cotton Seed Oil + 80% Diesel
4. 30% Cotton Seed Oil + 70% Diesel
5. 40% Cotton Seed Oil + 60% Diesel
6. 50% Cotton Seed Oil + 50% Diesel
7. 60% Cotton Seed Oil + 40% Diesel

6. RESULTS AND DISCUSSIONS

Experiments were conducted when the engine was fuelled with Cotton Seed Oil and their blends with diesel in proportions of 20:80, 30:70 and 40:60 (by volume) which are generally called as CSO-20, CSO-30 and CSO-40 respectively. The experiment covered a range of loads.

The performance of the engine was evaluated in terms of brake specific fuel consumption, brake thermal efficiency and volumetric efficiency. The emission characteristics of the engine were studied in terms, concentration of HC and CO. The results obtained for Cotton Seed Oil and their blends with diesel were compared with the results of diesel.

TABLE NO 1.2 Performance And Emission Test Results At Pure Diesel

S.N0	Load	Speed	Time	B.P	TFC	I.P	F.P	Heat Input	BSFC	η_{bth}	η_{ith}	η_{mech}	η_{vol}	BMEP	IMEP	CO	HC
	W	Rpm	Sec	kW	kg/s $*10^{-4}$	kW	kW	kW	Kg/kWh	%	%	%	%	kN/m^2	kN/m^2	%vol	ppm
1	1000	765	8.31	1.26	2.04	2.51	1.25	8.77	0.58	14.36	28.62	50.19	49.90	208.51	415.38	0.119	0
2	2000	724	6.03	2.12	2.80	3.37	1.25	12.05	0.47	17.59	27.96	62.90	53.12	370.71	589.28	0.221	2
3	3000	715	4.23	2.99	4	4.24	1.25	17.2	0.48	17.38	24.65	70.51	57.54	529.42	750.75	0.33	7
4	4000	699	3.98	3.69	4.25	4.94	1.25	18.27	0.41	20.19	27.03	74.69	60.14	668.32	894.71	0.098	1
5	5000	695	3.25	4.08	5.22	5.33	1.25	22.44	0.46	18.18	23.75	76.54	61.77	743.21	970.91	0.029	0

TABLE NO 1.3 Performance And Emission Test Results At CSO 10%

S.N0	Load	Speed	Time	B.P	TFC	I.P	F.P	Heat Input	BSFC	η_{bth}	η_{ith}	η_{mech}	η_{vol}	BMEP	IMEP	CO	HC
	W	Rpm	Sec	kW	kg/s $*10^{-4}$	kW	kW	kW	Kg/ kW h	%	%	%	%	kN/m^2	kN/m^2	%vol	ppm
1	1000	737	8.79	1.24	1.91	1.7	0.5	5.088	0.55	24.37	33.41	72	50.97	213.00	292.02	0.161	0
2	2000	721	6.54	2.071	2.66	2.571	0.5	11.37	0.44	18.21	22.61	80	53.34	363.64	451.44	0.151	0
3	3000	710	5.24	2.92	3.22	3.42	0.5	13.76	0.39	21.22	24.86	85	55.42	520.66	609.82	0.143	0
4	4000	700	4.15	3.57	4.08	4.07	0.5	17.44	0.41	20.47	23.37	87	57.49	645.66	736.09	0.122	0
5	5000	685	3.47	4.08	4.88	4.58	0.5	20.86	0.43	19.55	21.95	89	61.3	754.06	846.47	0.11	0

TABLE NO 1.4 Performance And Emission Test Results At CSO 20%

S.N0	Load	Speed	Time	B.P	TFC	I.P	F.P	Heat Input	BSFC	η_{bth}	η_{ith}	η_{mech}	η_{vol}	BMEP	IMEP	CO	HC
	W	Rpm	Sec	kW	kg/s $*10^{-4}$	kW	kW	kW	Kg/ kW h	%	%	%	%	kN/m^2	kN/m^2	%vol	ppm
1	1000	735	8.9	1.24	1.88	1.74	0.5	7.99	0.54	15.52	21.77	71	54.76	213.58	299.70	0.001	0
2	2000	724	6.38	2.07	2.63	2.57	0.5	11.18	0.47	18.51	22.98	80	59.29	361.96	449.39	0.004	0
3	3000	712	4.70	2.85	3.61	3.35	0.5	15.34	0.45	18.57	21.83	85	62.81	506.75	595.66	0.006	0
4	4000	699	4.24	3.71	4	4.21	0.5	17.00	0.38	21.82	24.76	88	65.25	671.95	762.50	0.009	0
5	5000	684	3.31.	4.08	5.11	4.58	0.5	21.72	0.45	18.78	21.08	89	61.45	755.16	847.70	0.008	0

TABLE NO 1.5 Performance And Emission Test Results At CSO 30%

S.N0	Load	Speed	Time	B.P	TFC	I.P	F.P	Heat Input	BSFC	η_{bth}	η_{ith}	η_{mech}	η_{vol}	BMEP	IMEP	CO	HC
	W	Rpm	Sec	kW	kg/s $*10^{-4}$	kW	kW	kW	Kg/ kW h	%	%	%	%	kN/m^2	kN/m^2	%vol	ppm
1	1000	734	7.13	1.21	2.361	2.46	1.25	9.98	0.70	12.12	24.64	49	49.96	208.70	424.30	0.002	1
2	2000	720	6.50	2.07	2.611	3.32	1.25	11.03	0.45	18.75	30.07	62	54.65	363.97	583.77	0.002	2
3	3000	707	4.93	2.85	3.44	4.1	1.25	14.54	0.43	19.6	28.98	69	56.93	510.34	734.17	0.007	2
4	4000	690	4.07	3.60	4.166	4.85	1.25	17.61	0.41	20.44	27.54	74	55.74	660.52	889.87	0.007	3
5	5000	677	3.50	4.30	4.83	5.55	1.25	20.42	0.40	21.05	27.17	77	62.09	804.11	1037.8	0.009	4

TABLE NO 1.6 Performance And Emission Test Results At CSO 40%

S.N0	Load	Speed	Time	B.P	TFC	I.P	F.P	Heat Input	BSFC	η_{bth}	η_{ith}	η_{mech}	η_{vol}	BMEP	IMEP	CO	HC
	W	Rpm	Sec	kW	kg/s $*10^{-4}$	kW	kW	kW	Kg/ kW h	%	%	%	%	kN/m^2	kN/m^2	%vol	ppm
1	1000	742	7.9	1.24	2.13	2.24	1.2	8.95	0.62	13.85	25.02	55	57.86	211.57	382.19	0.001	1
2	2000	730	6.24	2.10	2.72	3.30	1.2	11.43	0.46	18.37	28.87	63	60.03	364.19	572.30	0.003	1
3	3000	718	4.94	2.73	3.41	3.93	1.2	14.33	0.45	19.05	27.42	69	63.5	481	692.95	0.012	0
4	4000	703	4.22	3.69	4.02	4.89	1.2	16.09	0.39	22.93	30.39	75	68.7	664.5	880.62	0.024	0
5	5000	690	3.57	4.30	4.95	5.5	1.2	19.96	0.39	21.54	27.55	78	58.3	788	1009.1	0.027	0

TABLE NO 1.7 Performance And Emission Test Results At CSO 50%

S.N0	Load	Speed	Time	B.P	TFC	I.P	F.P	Heat Input	BSFC	η_{bth}	η_{ith}	η_{mech}	η_{vol}	BMEP	IMEP	CO	HC
	W	Rpm	Sec	kW	kg/s $*10^{-4}$	kW	kW	kW	Kg/ kW h	%	%	%	%	kN/m^2	kN/m^2	%vol	ppm
1	1000	730	8.50	1.21	2	2.41	1.2	8.36	0.59	14.47	28.82	50	52.68	209.84	417.95	0.002	1
2	2000	716	6.20	2.12	2.72	3.32	1.2	11.36	0.46	18.66	29.22	63	56.21	374.85	587.03	0.003	0
3	3000	698	5.66	2.85	3	4.05	1.2	12.54	0.37	22.72	32.29	70	58.94	516.92	734.57	0.004	1
4	4000	683	4.55	3.51	3.72	4.71	1.2	15.54	0.38	22.58	30.30	74	62.20	650.61	873.04	0.003	0
5	5000	671	3.77	4.30	4.5	5.50	1.2	18.81	0.37	22.86	29.23	78	66.64	811.30	1037.7	0.008	0

TABLE NO 1.8 Performance And Emission Test Results At CSO 60%

S.N0	Load	Speed	Time	B.P	TFC	I.P	F.P	Heat Input	BSFC	η_{bth}	η_{ith}	η_{mech}	η_{vol}	BMEP	IMEP	CO	HC
	W	Rpm	Sec	kW	kg/s $*10^{-4}$	kW	kW	kW	Kg/ kW h	%	%	%	%	kN/m^2	kN/m^2	%vol	ppm
1	1000	730	8.52	1.23	1.97	2.73	1.5	8.18	0.57	15.03	33.37	45	56.39	213.319	473.44	0.001	0
2	2000	718	6.34	2.04	2.66	3.54	1.5	11.05	0.47	18.46	32.03	57	57.33	359.69	624.18	0.001	1
3	3000	710	5.17	2.85	3.27	4.35	1.5	13.62	0.41	20.92	31.93	65	61.75	508.18	775.64	0	3
4	4000	697	4.51	3.69	3.75	5.19	1.5	15.58	0.36	23.68	33.31	71	65.47	670.23	942.68	0.002	0
5	5000	691	3.96	4.30	4.27	5.8	1.5	17.75	0.35	24.22	32.67	74	68.63	787.81	1062.6	0.001	0

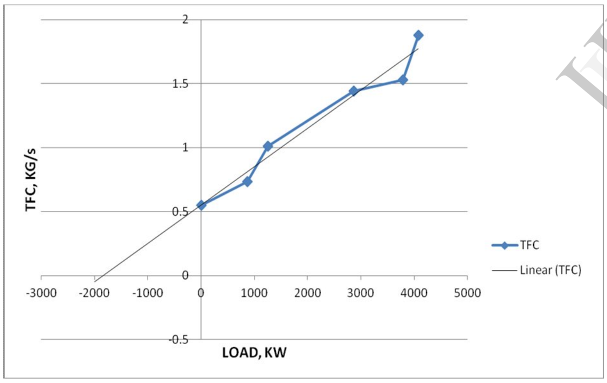

FIG NO.2.Friction Power of Diesel

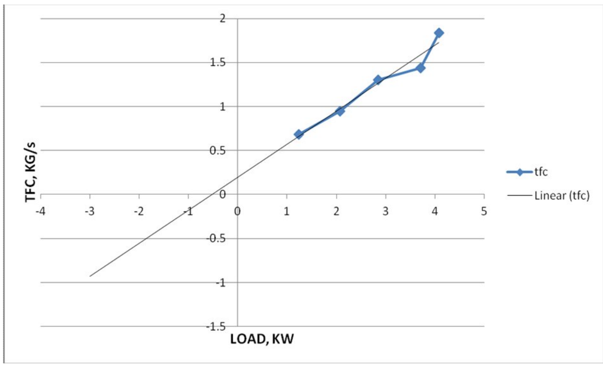

FIG NO.4.Friction Power While Using CSO20

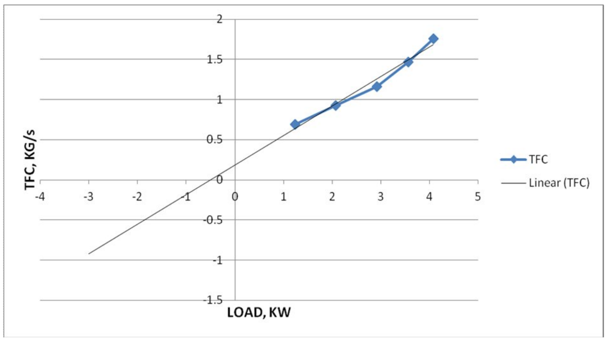

FIG NO.3.Friction Power Using CSO 10

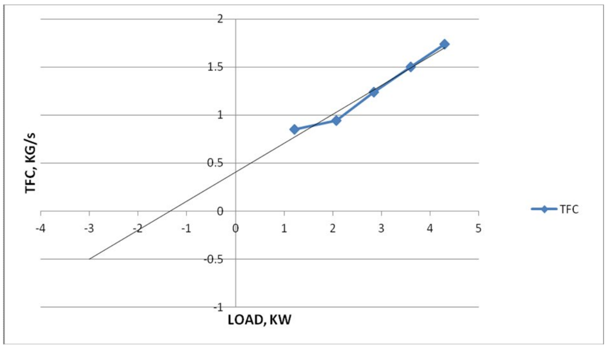

FIG NO.5.Friction Power While Using CSO30

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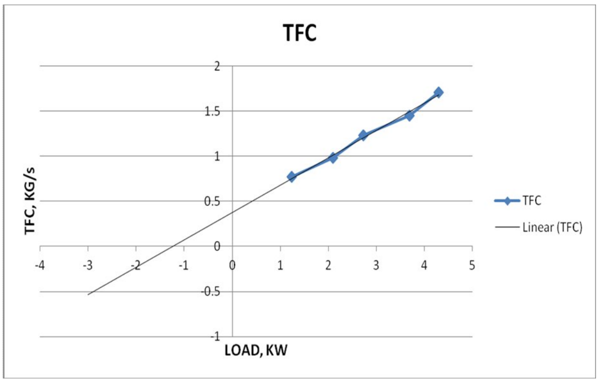

FIG NO.6.Friction Power While Using CSO40

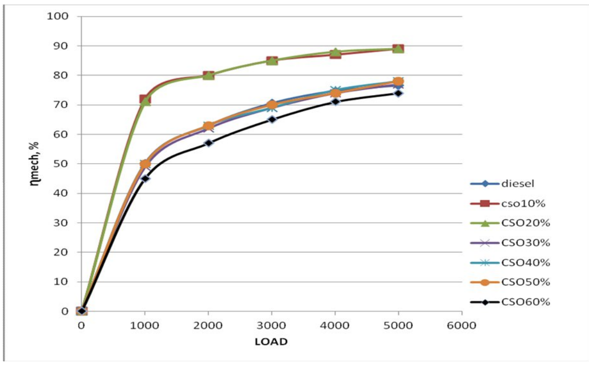

FIG NO.10. Load v/s Mechanical Efficiency

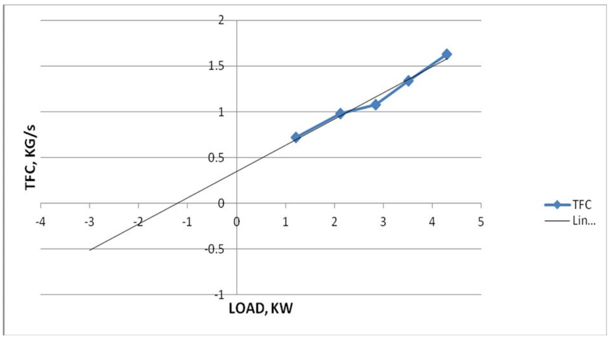

FIG NO.7.Friction Power While Using CSO50

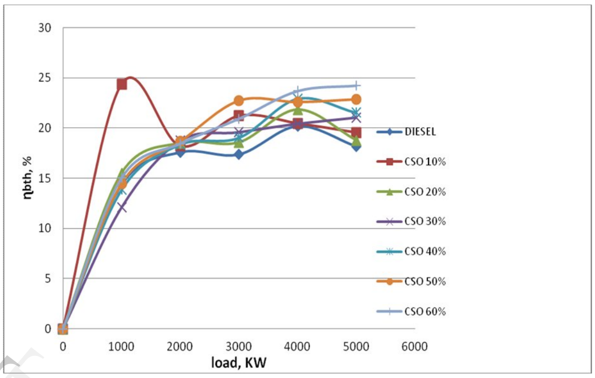

FIG NO.11. Load v/s Brake Thermal Efficiency

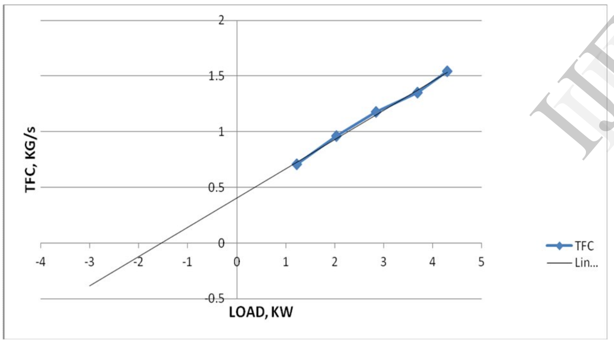

FIG NO.8.Friction Power While Using CSO60

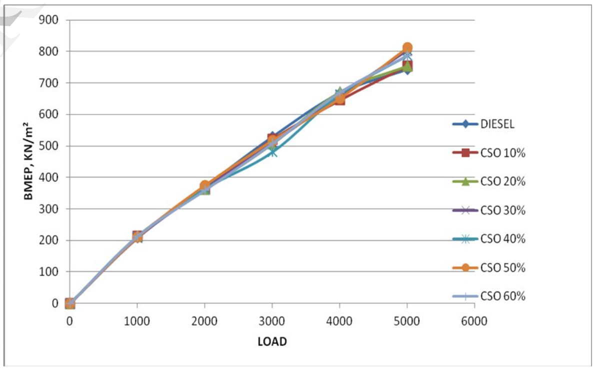

FIG NO.12. Load v/s Brake Mean Effective Pressure

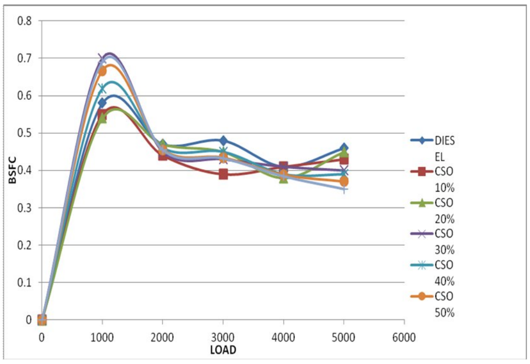

FIG NO.9.Load v/s BSFC

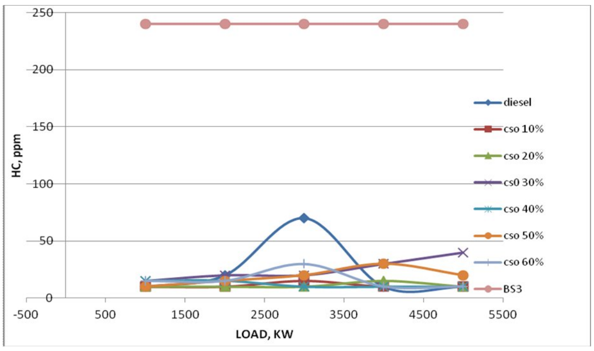

FIG NO.13. Load v/s Hydro Carbon

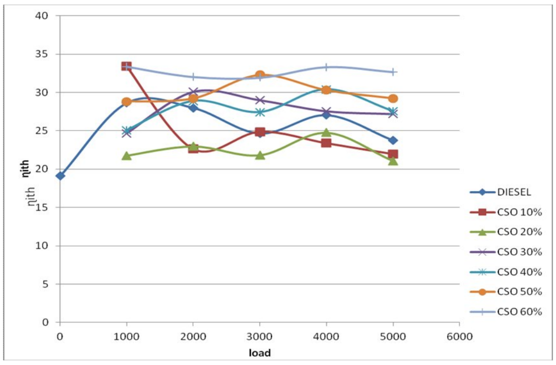

FIG NO.14. Load v/s Indicated Thermal Efficiency

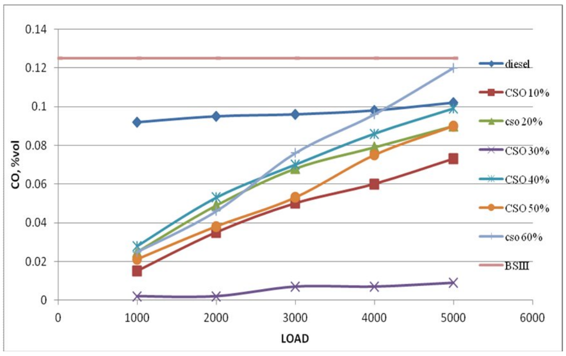

FIG NO.16. Load v/s CO

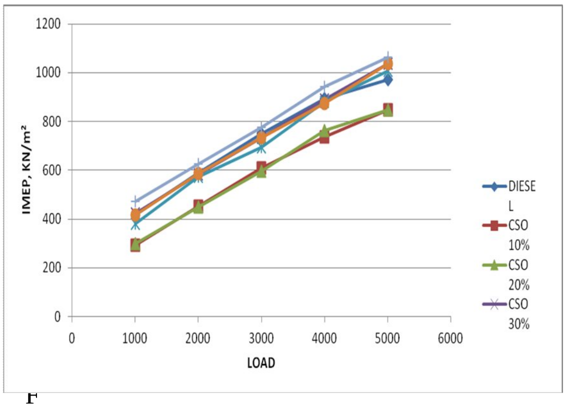

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FIG NO.15. Load v/s Indicated Mean Effective Pressure

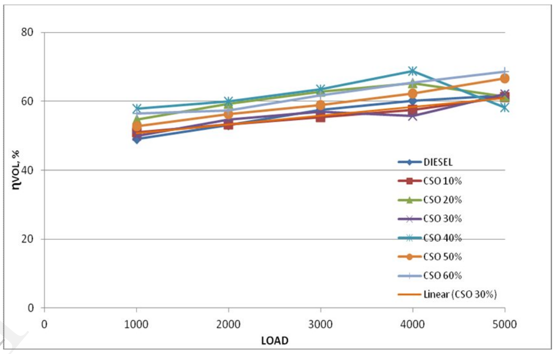

FIG NO.17. Load v/s Volumetric Efficiency

7. CONCLUSIONS

Following are the conclusions based on the experimental results obtained while operating single cylinder air cooled diesel engine fuelled with Cotton Seed Oil and its diesel blends.

- The blends of Cotton Seed Oil show lowest specific fuel consumption than the diesel at part loads. B.S.F.C is decrease with the blend of CSO.
- Brake Thermal efficiency of the tested diesel engine is improved when it is fuelled with cotton seed oil-diesel blends.
- Mechanical efficiency of engine with CSO blends is higher compared to Diesel fuel operation is observed.
- Brake mean effective pressure is also increased as the percentage of the Cotton Seed Oil increases with the diesel. But this increment in Brake mean effective power is insignificant.
- Actual Breathing capacity of the engine also slightly increased which leads to increase in volumetric efficiency. It is noted that the volumetric efficiency is raised as the blend of the Cotton seed oil increases in the diesel.
- CO emission decrease with increase in percentage of Cotton Seed Oil in the fuel.
- HC emissions of Cotton Seed Oil and its diesel blends are lower than that of diesel

From the above analysis the main conclusion is Cotton Seed Oil and its diesel blends are suitable substitute for diesel as they produce lesser emissions than diesel upto a load of 3000W and have satisfactory combustion and performance characteristics. And from the results and discussion we can observe that Cotton Seed Oil blend of 50% gives better performance in various aspects, hence it is better to use CSO50 for optimum usage.

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